United States Environmental Protection Agency
Nutrient Scientific Technical Exchange Partnership and Support
Nutrient STEPS

N-STEPS CIRCULAR

BIMONTHLY NUTRIENT NEWS FOR EPA'S REGIONAL NUTRIENT COORDINATORS

March 2017

In This Issue

For more information about this circular, contact
Jacques Oliver
Oliver.Jacques@epa.gov
202-566-0630
EPA Office of Water
Office of Science and Technology
Health and Ecological Criteria Division

Additional information about nutrients can be found at www.epa.gov/nutrientpollution.

National News

2017 Technical Webinar Series

The N-STEPS program is pleased to announce its 2017 technical webinar series highlighting nutrient pollution science along the freshwater to marine continuum. These webinars are intended as forums to provide EPA and our co-regulatory state and tribal scientists with the latest scientific developments related to numeric nutrient criteria. Five webinars are anticipated this year. Speakers will include:

- April 27 - Amy Rosemond, University of Georgia
- June 21 - Ryan King, Baylor University
- August 16 - Paul Bukaveckas, Virginia Commonwealth University
- September 12 - Michael Pace, University of Virginia
- October 17 - John Lehrter, University of South Alabama

All webinars will begin at 3:00 PM Eastern time. Contact Galen Kaufman (kaufman.galen@epa.gov, 202-566-1971) if you have any questions related to the webinar series.

Version 1.0 Water Quality Indicators Tool Released to Government Audience

The Water Quality Indicators (WQI) Map (requires EPA LAN ID and password), which was released by EPA's Office of Enforcement and Compliance Assurance, allows users to identify the location of lakes, rivers, and streams with elevated concentrations of water pollutants (phosphorus [P] and nitrogen [N]) and then overlay these locations with information about Clean Water Act National Pollutant Discharge Elimination System (NPDES) permitted upstream dischargers. Users can also view information about any related water quality impairment. The mapping interface allows users to decide how to view summary data for millions of ambient water quality monitoring records from EPA's STORET and USGS's National Water Information System (NWIS) databases.

Version 1.0 of the WQI includes a number of enhancements to improve a user's ability to find water quality hotspots and potential pollution sources. New features are based on feedback from beta review and include:

- Top 50–500 stations: WQI will display the stations with the highest monitoring values. This will take into account any user defined filters (e.g., if a user filters by the state of Virginia and to stations with a minimum of 10 samples, the WQI will display top 50–500 stations in Virginia with 10 or more samples).

- Customizable water quality criteria and breakpoints
- Harmful Algal Bloom (HAB) criteria
- Ability to choose a basemap
- Ability to filter stations by minimum number of samples
- New optional layers: county level concentrated animal feeding operation (CAFO) density and hydrologic unit code (HUC) boundary layers

Regional News

Idaho, Oregon, and Washington: N-STEPS Support for Developing Nutrient Thresholds for Streams

Author: Rochelle Labiosa, PhD, EPA Region 10

Idaho, Oregon, and Washington have narrative criteria for distinguishing nutrient conditions that contribute to the production of undesirable or nuisance aquatic life, or have aesthetic impacts; and numeric criteria for dissolved oxygen, pH, and other water quality variables related to nutrients. These criteria should be linked to numeric nutrient thresholds for consistent implementation of section 303(d) impairment listing determinations, NPDES water quality-based effluent limits (WQBEL) for permitting, and Total Maximum Daily Load (TMDL) calculations. Therefore, the Idaho Department of Environmental Quality, Oregon Department of Environmental Quality, and Washington State Department of Ecology, with collaboration and direct contractor support from the EPA N-STEPS program, have been identifying total nitrogen (TN) and total phosphorus (TP) nutrient threshold values for wadeable streams using regional data, reference conditions, and links between cause and response variables, including periphyton diatom multi-metric indices. Idaho's final report will be completed by spring 2017, while Oregon's and Washington's projects are scheduled to be completed by the end of FY 2017.

Although each project relies upon comparable datasets, each state has different focal points. In each states' approach, datasets from national probabilistic studies were combined with state datasets, with national datasets comprising all ecoregions that overlap with the individual state. For the Oregon analyses, for example, Idaho, Washington, and California data that are available for ecoregions in Oregon were included in the dataset used in the analysis. For all of the projects, initial startup time was spent on reconciling diatom taxonomy for the national datasets and state datasets; the national diatom datasets taxonomies now have been reconciled for all conterminous states (lower 48) and are available for other states and tribes to use[1]. For the stressor-response analyses, different types of analyses have provided distinct information. For example, Idaho included in its stressor-response analyses identification of qualitative aesthetic thresholds (identified by monitoring programs) and found that they displayed distinct relationships with the nutrient thresholds identified by site classification schemes. Whereas for Oregon, structured equation models are in development to elucidate the role of confounding factors in influencing stressor-response relationships. We will soon test the relationships that have been developed with new data that Oregon has been collecting over the past year. We appreciate the support that N-STEPS has provided Region 10 states in identifying appropriate nutrient thresholds to more effectively implement Clean Water Act Programs.

[1] https://westerndiatoms.colorado.edu/

Expert Picks

DON as a Source of Bioavailable Nitrogen for Phytoplankton

Bronk, D.A., J.H. See, P. Bradley, and L. Killberg. 2007. Published in *Biogeosciences*, Volume 4:283–296

— Picked by Yini Shangguan, PhD, 2017 John A. Knauss Fellow, EPA Office of Water, Office of Science and Technology

Review: This paper reviews the importance of dissolved organic nitrogen (DON) to phytoplankton. The authors wish to discard the traditional dogmas that: (1) DON is largely refractory and thus not bioavailable to phytoplankton, and (2) DON is used to fuel bacterial rather than phytoplankton production. An estimate of 14–90% of the TN in coastal zones is in organic form. A higher fraction of DON is bioavailable than previously thought, including from some high molecular weight compounds. Several methods, including size fractionation technique and flow cytometer sorting, are reviewed to trace N uptake by bacteria and phytoplankton. It is important to note that some HABs species (e.g., *Prorocentrum minimum*, *Lingulodinium polyedrum*, *Aureococcus anophagefferens*) are capable of using DON as a nutrition source. To understand mechanisms phytoplankton use to access the DON pool, enzymatic breakdown, pino- and phagocytosis, and photochemical decomposition are reviewed. The authors conclude that, based on the current study, DON is composed of two distinct pools, the large refractory pool and the highly labile compounds, which contribute to both autotrophic and heterotrophic production. They also strongly call for the inclusion of DON in N loading budgets.

Emerging Tools for Continuous Nutrient Monitoring Networks: Sensors Advancing Science and Water Resources Protection

Pellerin, B.A., B.A. Stauffer, D.A. Young, D.J. Sullivan, S.B. Bricker, M.R. Walbridge, G.A. Clyde, Jr., and D.M. Shaw. 2016. Published in *Journal of the American Water Resources Association*: Volume 52:993–1008, doi:10.1111/1752-1688.12386

— Picked by Elizabeth Hinchey Malloy, PhD, EPA, Great Lakes National Program Office

Review: This paper highlights advances in nutrient sensor technology and sensor data management that have poised sensors to become critical tools in water quality management. By focusing on nitrate sensors (which are the most mature of the *in situ* nutrient sensor technologies), the authors describe the types of applications in freshwater and coastal environments that are likely to benefit from continuous, real-time water quality data. They also highlight several near-term opportunities for federal agencies, as well as the broader scientific and management community, that will help accelerate sensor development, build and leverage sites within a national network, and develop open data standards and data management protocols that are key to realizing the benefits of a large scale, integrated monitoring network. Advantages and disadvantages of commercially available nutrient sensor technologies are also reviewed. The team of authors is comprised of scientists from federal agencies (USGS, EPA, National Oceanic and Atmospheric Administration, U.S. Department of Agriculture Agricultural Research Service, and U.S. Army Corps of Engineers) and academia (University of Louisiana at Lafayette).

Some highlights include:

- *In situ* nutrient sensors can provide accurate and timely information on nutrient concentrations at multiple scales because they offer two fundamental advantages over traditional discrete sampling approaches: (1) data are collected at a much higher temporal frequency and (2) data can be disseminated in real time.
- Nutrient sensors are of interest to managers because of the well-known adverse impacts of nutrient enrichment on coastal hypoxia, HABs, and impacts to human health.

- At the watershed scale, continuous nitrate monitoring provides data for calculating nutrient loading and understanding the drivers of changes in water quality. These high-frequency data are also critical to characterizing variability in surface water nutrient concentrations, especially during hydrologic events and during periods when instream nutrients are produced, consumed, or altered prior to downstream export. Continuous nutrient monitoring can also improve the accuracy and reduce the uncertainty of nutrient load estimates from the edge-of-field and guide implementation and evaluation of best management practices at both the field and watershed scales.
- Examples where sensors have been used to characterize coastal nutrient concentrations to better predict phytoplankton growth and HAB development are provided.
- The concurrent emergence of new tools to integrate, manage, and share large datasets (dubbed the "data deluge" by the authors) is critical to the successful use of nutrient sensors and has made it possible for the field of continuous monitoring to rapidly move forward.

Example of sensor applications in the Great Lakes:

- Under the Great Lakes Restoration Initiative, USGS scientists are collecting water-flow and water-quality data at 26 tributary sites using multi-sensor water quality probes. These sites are being monitored to provide baseline information, provide support for measuring restoration progress, and demonstrate the ability to reduce monitoring costs through the use of continuous *in situ* water-quality sensors as surrogates for traditional manual sampling techniques. At several of these sites, USGS scientists are also beginning to implement the use of sensors for measuring continuous concentrations of nutrients such as phosphorus and nitrogen.

Global Riverine N and P Transport to Ocean Increased during the 20th Century despite Increased Retention along the Aquatic Continuum

Beusen, A.H.W., A.F. Bouwman, L.P.H. Van Beek, J.M. Mogollón, and J.J. Middelburg. 2016. Published in *Biogeosciences*. Volume 13, 2441–2451. doi:10.5194/bg-13-2441-2016

— Picked by Amy Shields, PhD, EPA Region 7

Review: How did global aquatic ecosystems function in the 20th century in response to increased nitrogen and phosphorus inputs? Our Netherlands colleagues published the first paper looking at novel ways to model, forecast, and hindcast the delivery of nutrients to aquatic ecosystems. One of those authors, Dr. Jack Middelburg of Utrecht University, is rather credible on the subject having been recognized by the American Society of Limnology and Oceanography with the G. Evelyn Hutchinson Award in 2016 for his "pivotal contribution to the development of concepts and models incorporating the role of aquatic biota on carbon and nutrient cycling in aquatic ecosystems."

This paper highlights that rivers are the primary transport of nitrogen and phosphorus to the coasts and significantly impact ocean chemistry. The reactive nitrogen from rivers and streams are now double that of pre-industrial concentrations and phosphorus has increased by three times. These significant increases in nutrient loads are due to anthropogenic pressures such as agriculture activity and wastewater discharges.

Many other peer-reviewed articles have observed the increased transport and delivery of nitrogen and phosphorus to aquatic systems. This paper stands out because it was the first paper to include all major aquatic nutrient sources with a global modeling approach looking to the past (20th century) for answers. The model employed in this study, the Integrated Model to Assess the Global Environment–Global Nutrient Model (IMAGEGNM; Beusen et al. 2015), was useful in predicting the impacts of variable hydrology and other long term changes in nitrogen and phosphorus inputs to rivers and streams. Figure 2 in the article shows that the Missouri River's long-term time series compared well with their simulated results from the 1970s to 2000 (root mean square error less than 50%).

It is also well known that global nutrient delivery increases were also coupled with the increase in stream removal of nitrogen and phosphorus. However, the authors assert that global nitrogen and phosphorus retention and removal in freshwater systems is due in part to the growing number of reservoirs globally. It turns out that the nutrient removal processes in our aquatic ecosystems cannot keep up with the nutrients that are delivered to them. Furthermore, human activities have increased the global molar N:P ratio in aquatic ecosystems and this imbalance is reflected in the riverine nutrient transport to the world's oceans.

As we continue to work with states and tribes on eutrophication there is much to learn about what is going on globally, especially in places of the world with significant nutrient impacts to aquatic ecosystems from agriculture, aquaculture, and wastewater. The authors also note that the modeling of in-stream biogeochemistry is critical to modeling individual level processes, which may be able to better simulate nitrogen and phosphorus in different forms. This information should lead us to a better understanding and predictions of hypoxia, and HAB formation and persistence.

Cited Reference

Beusen, A.H.W., L.P.H. Van Beek, A.F. Bouwman, J.M. Mogollón, and J.J. Middelburg. 2015. Coupling global models for hydrology and nutrient loading to simulate nitrogen and phosphorus retention in surface water—description of IMAGE-GNM and analysis of performance. *Geoscientific Model Development* 8:4045–4067. doi:10.5194/gmd-8-4045-2015.

Publications

This Month's Focus: Nutrient Pollution and Cyanobacteria

- **Nitrogen constrains the growth of late summer cyanobacterial blooms in Lake Erie**
  Chaffin, J.D., T.B. Bridgeman, and D.L. Bade. 2013. *Advances in Microbiology* 3(6A):16–26.
- **Cyanobacteria as biological drivers of lake nitrogen and phosphorus cycling**
  Cottingham, K.L, H.A. Ewing, M.L. Greer, C.C. Carey, and K.C. Weathers. 2015. *Ecosphere* 6(1):1–19.
- **Effects of increasing nitrogen and phosphorus concentrations on phytoplankton community growth and toxicity during *Planktothrix* blooms in Sandusky Bay, Lake Erie**
  Davis, T.W., G.S. Bullerjahn, T. Tuttle, R.M. McKay, and S.B. Watson. 2015. *Environmental Science and Technology* 49:7197–7207.
- **Evidence for dissolved organic nitrogen and phosphorus uptake during a cyanobacterial bloom in Florida Bay**
  Glibert, P.M., C.A. Heil, D. Hollander, M. Revilla, A. Hoare, J. Alexander, and S. Murasko. 2004. *Marine Ecology Progress Series* 280:73–83.
- **The dual role of nitrogen supply in controlling the growth and toxicity of cyanobacterial blooms**
  Gobler, C.J., J.M. Burkholder, T.W. Davis, M.J. Harke, T. Johengen, C.A. Stow, and D.B. Van de Waal. 2016. *Harmful Algae* 54:87–97.
- **Biochemical and ecological control of geosmin and 2-methylisoborneol in source waters**
  Jüttner, F., and S.B. Watson. 2007. *Applied and Environmental Microbiology* 73(14):4395–4406.
- **Nitrogen forms influence microcystin concentration and composition via changes in cyanobacterial community structure**
  Monchamp, M.-E., F.R. Pick, B.E. Beisner, and R. Maranger. 2014. *PLOSOne* 9(1): e85573.
- **Environmental conditions that influence toxin biosynthesis in cyanobacteria**
  Neilan, B.A., L.A. Pearson, J. Muenchhoff, M.C. Moffitt, and E. Dittmann. 2012. *Environmental Microbiology* 15(5):1239–1253.
- **Nitrogen fixation may not balance the nitrogen pool in lakes over timescales relevant to eutrophication management**
  Scott, J.T., and M.J. McCarthy. 2010. *Limnology and Oceanography* 55(3):1265–1270.
- **Status, causes and controls on cyanobacterial blooms in Lake Erie**
  Steffen, M.M., B.S. Belisle, S.B. Watson, G.L. Boyer, and S.W. Wilhelm. 2014. *Journal of Great Lakes Research* 40:215–225.

Upcoming Meetings and Conferences

International Assocation for Great Lakes Research

May 15–19, 2017
Detroit, MI

Society for Freshwater Science

June 4–8, 2017
Raleigh, NC

Coastal and Estuarine Research Federation

November 5–9, 2017
Providence, RI